

WILLINGNESS TO RESPOND TO RADIOLOGICAL DISASTERS AMONG FIRST RESPONDERS IN ST. LOUIS, MISSOURI

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During radiological disasters, firefighters and emergency medical services personnel are expected to report to work and engage in response activities; however, prior research exploring willingness to respond to radiological disasters among first responders has considered only radiological terrorism scenarios and not nonterrorism radiological scenarios. The goal of this study was to compare willingness to respond to terrorism and nonterrorism radiological disaster scenarios among first responders in St. Louis, Missouri, and to explore determinants of willingness to respond. Firefighters and emergency medical services personnel were surveyed about their willingness to respond to a dirty bomb detonation (terrorism) and a radioactive landfill fire (nonterrorism). McNemar's tests were used to assess differences in individual willingness to respond between the 2 scenarios and differences if requested versus required to respond. Chi-square tests were used to identify significant individual predictors of willingness to respond. Multivariate logistic regressions were used to determine final models of willingness to respond for both scenarios. Willingness to respond was lower for the dirty bomb scenario than the landfill scenario if requested (68.4% vs 73.0%; $P < .05$). For both scenarios, willingness to respond was lower if requested versus required to respond (dirty bomb: 68.4% vs 85.2%, $P < .001$; landfill: 73.0% vs 87.3%, $P < .001$). Normative beliefs, perceived susceptibility, self-efficacy, and perceived barriers were significant predictors of willingness to respond in the final models. Willingness to respond among first responders differed significantly between terrorism and nonterrorism radiological disasters and if requested versus required to respond. Willingness to respond may be increased through interventions targeting significant attitudinal and belief predictors and by establishing organizational policies that define expectations of employee response during disasters.

Keywords: Disasters, First responders, Willingness to respond, Radiation, Dirty bomb

INTRODUCTION

RADIOLOGICAL DISASTERS are naturally occurring or manmade events involving the release of radioactive materials and/or ionizing radiation. These may include

such events as industrial accidents or a radiological terrorism attack, where a radiological dispersion device or dirty bomb may be used. Radiological disasters can pose a serious health and safety risk for affected individuals and can subsequently pose a risk to first responders who provide emergency medical care and mitigation at the site of the

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incident.¹ Exposure to ionizing radiation can cause both immediate and long-term biological and genetic effects, resulting in DNA damage, organ dysfunction, and an increased lifetime risk for cancers in exposed individuals and their future progeny.²

During a radiological disaster, first responders will be expected to report to work to secure the scene, decontaminate victims, and provide lifesaving care. However, past research indicates that healthcare and public health professionals are less willing to report to work during a radiological event compared to all other types of natural and manmade disasters.^{3,4} For example, Brice et al assessed hospital workers' willingness to report to work and found that 72.6% would work during a snowstorm and 66.6% during a mass casualty incident, but only 39.4% were willing to work after a nuclear reactor accident.⁵ In addition, first responders' ability to work during radiological events has been found to be higher than their willingness to work.⁶ Researchers have previously assessed willingness to respond to radiological disasters among emergency medical services (EMS) personnel and found that they also are less willing to respond to a radiological event compared to other types of disasters.⁶⁻⁸

Determinants of willingness to work during radiological disasters among EMS personnel include self-efficacy, response efficacy, perceived responsibility, perceived safety during the event, perceived family preparedness, radiological disaster training received, and knowledge of radiological disaster preparedness.⁶⁻⁸ Concern for family and childcare or eldercare obligations have been found to be associated with less willingness to work during radiological disasters.⁶ Researchers have also found that willingness to work is lower when individuals are asked to respond versus when told they are required to work.⁹

Although previous studies have assessed EMS personnel's willingness to respond during a radiological terrorism attack, no research has explored their willingness to work during a naturally occurring radiological disaster. In addition, no prior research has assessed the willingness of firefighters to report to work during any type of radiological event. The purpose of this study was to assess willingness to respond to both terrorism and nonterrorism radiological scenarios among EMS personnel and firefighters and to identify attitudinal and behavioral factors that influence that decision.

METHODS

Between July 2018 and February 2019, EMS professionals and firefighters working at 2 of the largest first responder agencies in the St. Louis, Missouri, metro area were recruited to complete an anonymous questionnaire regarding their willingness to work during radiological disasters. One of the participating agencies covers all EMS and fire protection for the city of St. Louis; it consists of 30 stations that span more than 60 square miles. The second participating

agency has 18 stations that cover 590 square miles of the greater St. Louis suburban region; it consists only of EMS professionals. Recruitment took place onsite at both agencies and was conducted prior to an educational workshop. The suburban-based agency also used email recruitment. The questionnaire was available on paper and electronically through Qualtrics, an online survey program.

Instrument

The questionnaire was based on previous studies of healthcare workers' and public health professionals' willingness to respond during different disaster scenarios.^{3,4,10-12} In addition, questions specific to a local potential radiological disaster risk were added. Content validity was assessed using a panel of 12 US radiological disaster preparedness researchers. The content validity index (CVI) was computed for each item and found to be ≥ 0.8 for all questions; therefore, all items were kept. Some items were reworded to improve clarity and comprehension based on CVI panel feedback. Pilot testing was then conducted, using 10 first responders (5 EMS and 5 firefighters); individual items were further refined based on their feedback. The final questionnaire contained 65 questions plus demographic items.

In the survey, respondents were presented with 2 different radiological disaster scenarios: one involving a radiological terrorism scenario and the other a naturally occurring radiological disaster. The naturally occurring radiological disaster scenario was based on an actual potential risk to the greater St. Louis region: the St. Louis West Lake Landfill. The St. Louis West Lake Landfill is the site of an ongoing subsurface smoldering event that is near a region of buried radiological waste material. The potential threat of a radiological ash or steam plume that could occur should the subsurface smoldering event reach the radiological material has resulted in fear and anxiety among local residents.¹³ A subsurface smoldering event encroaching on radiological material in a landfill is unprecedented; however, this event is analogous to a transportation accident involving the accidental release of radiological materials or nuclear waste—essentially, a nonterrorism event involving the dissemination of radioactive material into the environment—an event that could occur with no prior warning.

The 2 disaster scenarios presented in the questionnaire consisted of the following:

1. *A radiological terrorism event:* A radioactive (dirty) bomb has exploded in downtown St. Louis. Thousands of people are flocking to emergency rooms throughout the greater St. Louis region. In this scenario, "going to work" means that you will be responding at the scene of the bombing.
2. *A naturally occurring/nonterrorism-related radiological event:* The subsurface smoldering event (ie, fire) at the St. Louis West Lake Landfill that started in the South Quarry, which contains traditional trash, has now

spread into the North Quarry area, which contains discarded radiological waste. After the fire and heat came into contact with the radiological materials, it generated a radioactive plume that is spreading throughout the region and threatening nearby residences. Nearby residents need to be evacuated. In this scenario, “going to work” means that you will be responding at the scene for fire control, provision of medical care, or helping residents evacuate into a safe area.

For each disaster scenario, participants were asked about their willingness to respond to that scenario if requested and if required to respond. Participants were asked 14 attitude/belief questions related to perceived severity, perceived susceptibility, self-efficacy, response efficacy, normative beliefs, perceived barriers, risk perceptions, institutional support, and role importance during radiological disasters. Respondents were also asked about their risk perceptions related to the West Lake Landfill, occupational radiation exposure, and the likelihood of a radiological disaster in the next 5 years. All attitudinal items were measured on a 5-point Likert-type scale, ranging from strongly agree to strongly disagree. Questionnaire items also included the amount and type of previous disaster response training received, prior participation in disaster exercises, and prior knowledge of the potential health threat posed by the West Lake Landfill. Participants were asked whether they had received 5 types of training for radiological disasters: a radiological dispersion device, a radiological exposure device, a radiological transportation incident, a nuclear reactor incident, and an improvised nuclear device/nuclear detonation. They could answer none, ≤ 1 hour, 2 to 3 hours, or ≥ 4 hours. Knowledge was assessed using a set of 15 true/false questions related to the routes and health effects of ionizing radiation exposure and protective measures to prevent exposure. Demographic variables, such as age, gender, race, education, and presence of children in the home, were also collected. The full survey instrument is available for review on request.

Data Analysis

All analyses were conducted using IBM SPSS Statistics for Windows version 24 (IBM Corp). Likert-scale questions were recoded and dichotomized, with “strongly agree” and “agree somewhat” representing “yes” and all other answers representing “no.” For the 15 knowledge questions, each correct answer was scored as 1 point, and a total knowledge score was calculated by summing the number of correct answers. This knowledge score consisted of a numeric variable with possible values ranging from 0 to 15.

Descriptive statistics were performed on all variables. A McNemar’s test was used to assess differences in willingness to respond to the terrorism and nonterrorism scenarios if requested versus if required, and to compare willingness to work during the dirty bomb versus landfill scenario. De-

terminants of willingness to work during each of the radiological disaster scenarios if requested were ascertained using multivariate logistic regressions, controlling for gender, occupation, and marital status. Purposeful selection was used to identify significant predictor variables through bivariate analyses, using an initial P value cutoff of .05. Variables examined in bivariate analysis included all of the attitude/belief questions, risk perceptions, the knowledge score, disaster training and exercise participation, and all demographic variables. Multivariate analyses used only variables that were significant during bivariate analyses. Nonsignificant variables were removed individually until only significant predictors remained. Only final models are reported. A critical P value of .05 was used for all analyses.

RESULTS

A total of 522 individuals from the 2 participating agencies were invited to take the survey; 433 individuals completed a survey (response rate of 83%). About two-thirds (64.2%, $n=278$) were firefighters; 35.8% ($n=155$) were EMS personnel. A summary of participant demographics and comparison of firefighters versus EMS personnel are presented in Table 1. Most respondents (89.1%, $n=386$) were male, and three-quarters (73.4%, $n=318$) were white. A third (32.8%, $n=142$) were between 31 and 40 years old, while half (52.6%, $n=228$) were over 41 years old. Two-thirds (66.7%, $n=289$) had completed some college coursework or had a 2-year degree, and another quarter (23.3%, $n=101$) had a 4-year degree or higher education background. Almost all (99.1%, $n=429$) were employed full time, and almost two-thirds (63.5%, $n=275$) had 11 or more years of work experience. Comparing across occupational groups, there were significant proportional differences between firefighters and EMS personnel for gender, age, race, education level, years of work experience, and marital status (Table 1).

Knowledge of the St. Louis West Lake Landfill

Participants were asked 2 questions regarding their knowledge of the St. Louis West Lake Landfill: the amount they had read or heard about the landfill and whether they had watched the HBO documentary about the landfill titled *Atomic Homefront*. They were also asked 5 risk perception questions related to the potential health risks posed by the landfill to themselves, their family or friends, or those who live close to the landfill. Approximately three-quarters reported that they believe the West Lake Landfill currently poses a risk of cancer or radiation exposure to those who live near the landfill (76.7% and 75.1%, respectively). Among those who reported not believing the landfill poses a current health risk ($n=108$), about a third

Table 1. Demographics of Survey Respondents

	Total (N=433) ^a % (n)	Firefighters (n=278) ^a % (n)	EMS (n=155) ^a % (n)	Fire vs EMS P Value ^b
Gender (male)	89.1 (386)	99.3 (276)	71 (110)	<.001
Age (years)				<.001
18-30	14.5 (63)	7.2 (20)	27.7 (43)	
31-40	32.8 (142)	31.7 (88)	34.8 (54)	
41-50	27 (117)	29.1 (81)	23.2 (36)	
≥51	25.6 (111)	32 (89)	14.2 (22)	
Race				.001
White	73.4 (318)	68 (189)	83.2 (129)	
Black	15.9 (69)	20.5 (57)	7.7 (12)	
All others	6.2 (27)	5.8 (16)	7.1 (11)	
Education				<.05
High school/GED or less	9.9 (43)	12.6 (35)	5.2 (8)	
Some college or 2-year degree	66.7 (289)	64 (178)	71.6 (111)	
4-year degree or more	23.3 (101)	23.4 (65)	23.2 (36)	
Employment status				NS
Part-time	0.9 (4)	0.7 (2)	1.3 (2)	
Full-time	99.1 (429)	99.3 (276)	98.7 (153)	
Years of work experience				<.001
≤1	4.8 (21)	3.6 (10)	7.1 (11)	
2-4	12.7 (55)	10.4 (29)	16.8 (26)	
5-10	18.9 (82)	15.1 (42)	25.8 (40)	
≥11	63.5 (275)	70.9 (197)	50.3 (78)	
Marital status				.001
Single/widowed	30.7 (133)	25.2 (70)	40.6 (63)	
Married/committed relationship	69.3 (300)	74.8 (208)	59.4 (92)	
Have child <18 in the household	51.3 (222)	50 (139)	53.5 (83)	NS
Spouse/significant other is a first responder	10.3 (31)	8.7 (18)	4.3 (13)	NS

^aDenominator varies due to missing data.

^bDetermined by χ^2 test.

Abbreviations: EMS, emergency medical services; GED, general education degree; NS, not significant.

(30.6%, n=33) believe that it could pose a health risk in the future. First responders were significantly more likely to report concern for their family's or friends' health compared to their own in relation to the buried radiological materials in the landfill (50.3% vs 40.9%, respectively, chi-square test [χ^2]=243, P <.001).

About half (45.3%, n=196) reported that they had read or heard a fair amount about the landfill; 11.1% (n=48) had read or heard a lot, 30.5% (n=132) had read or heard very little, and 13.2% (n=57) had not read or heard anything about it. About a quarter (26.3%, n=114) reported having seen *Atomic Homefront*. Those who had read or heard a lot to a fair amount about the landfill reported higher risk perceptions related to the health risks associated with the landfill (P <.001 for all comparisons), except in relation to the possible health risk it posed to themselves; there were no differences in perceived personal health risk from the landfill and the amount they had read or heard about the landfill. Those who watched *Atomic Homefront* reported a significantly higher perceived risk to their own health from the landfill ($\chi^2=5.3$, P <.001), perceived health risk to their family or friends ($\chi^2=16.5$, P <.001), perceived radiation exposure risk to anyone living by the landfill ($\chi^2=24$, P <.001), and perceived risk of cancer to

anyone living close to the landfill ($\chi^2=23$, P <.001). However, neither the amount an individual had read or heard about the landfill nor having watched *Atomic Homefront* were associated with their willingness to report to work in the landfill scenario, whether requested or required to work.

Willingness to Respond If Requested vs If Required

Respondents were asked if they were willing to respond if requested and if required to the radiological disaster scenarios consisting of a dirty bomb and the St. Louis West Lake Landfill. Table 2 describes results of the McNemar's tests comparing willingness to respond between the scenarios. Responders were significantly less likely to respond to the dirty bomb scenario if requested versus if required (68.4% vs 85.2%, $\chi^2=140.8$, P <.001); similarly, they were significantly less likely to respond to the landfill scenario if requested versus if required (73% vs 87.3%, $\chi^2=137.9$, P <.001). When comparing willingness to respond to either scenario if requested, significantly fewer responders were willing to respond to the dirty bomb

Table 2. Willingness to Respond to Radiological Disaster Scenarios

<i>Scenario</i>	<i>Yes, % (n)</i>	<i>P Value^a</i>
Willingness to respond to dirty bomb (requested)	68.4 (269)	<.001
Willingness to respond to dirty bomb (required)	85.2 (369)	
Willingness to respond to landfill (requested)	73.0 (316)	<.001
Willingness to respond to landfill (required)	87.3 (378)	
Willingness to respond to dirty bomb (requested)	68.4 (269)	<.05
Willingness to respond to landfill (requested)	73.0 (316)	
Willingness to respond to dirty bomb (required)	85.2 (369)	NS
Willingness to respond to landfill (required)	87.3 (378)	

^aDetermined by McNemar's test.
Abbreviation: NS, not significant.

scenario than the landfill scenario (68.4% vs 73%, $\chi^2 = 201.4$, $P < 0.05$). There was no significant difference in willingness to respond if required between the dirty bomb scenario and the landfill scenario (85.2% vs 87.3%).

Knowledge and Training and Willingness to Respond

Participants were asked 15 knowledge questions and scored 1 point for each correct answer. Participants' average knowledge score was 8.6 (ie, 57.3% correct), with a range of 5 to 13 out of 15. Those willing to respond if requested to a dirty bomb had significantly higher knowledge scores than those unwilling to respond (8.72 vs 8.35, respectively; Student's *t*-test [*t*] = -2.19, $P < .05$). There was no significant difference in mean knowledge scores between those willing versus those unwilling to respond to the dirty bomb scenario if required, nor for either landfill scenario. Prior radiological disaster training (radiological exposure device and nuclear reactor incident training) and participation in a radiological disaster exercise were associated with willingness to respond to the dirty bomb scenario if requested ($P < .05$ for all comparisons). Other types of radiological disaster training were not associated with willingness to respond to a dirty bomb. Prior radiological disaster training (radiological exposure device and radiological transportation incident training) and participation in a radiological disaster exercise were associated with willingness to respond to the landfill if requested ($P < .05$ for all comparisons). No other prior training variables were significant predictors of willingness to respond when requested to the landfill scenario.

Determinants of Willingness to Respond to a Dirty Bomb

First responders' attitudes and beliefs differed significantly when comparing those willing and those unwilling to respond to the dirty bomb scenario (Table 3). On bivariate

analysis, those willing to respond to the dirty bomb scenario if requested were significantly more likely than those unwilling to respond to agree the event could have serious negative health effects ($\chi^2 = 22.1$, $P < .001$); have perceived safety working during the event ($\chi^2 = 43.8$, $P < .001$); believe their employer would provide them with personal protective equipment and would take precautions to protect them ($\chi^2 = 19.7$ and $\chi^2 = 9.6$, respectively; $P < .01$); know how to and would be able to perform their duties ($\chi^2 = 33$ and $\chi^2 = 50.1$, respectively; $P < .001$); have perceived job importance ($\chi^2 = 40.6$, $P < .001$); believe their coworkers will work and their employer expects them to work during the event ($\chi^2 = 69.1$ and $\chi^2 = 30.4$, respectively; $P < .001$); perceive responsibility to work ($\chi^2 = 109.2$, $P < .001$); and believe their family can function without them during the event ($\chi^2 = 43.6$, $P < .001$). Determinants of willingness to respond if requested to a dirty bomb on multivariate logistic regression controlling for gender, occupation, and marital status included believing they have a responsibility to work (odds ratio [OR] 9.0; 95% confidence interval [CI], 4.5-18.2; $P < .001$), believing their coworkers were likely to work during the event (OR 3.5; 95% CI, 2.0-5.9; $P < .001$), feeling safe while working during the event (OR 2.1; 95% CI, 1.1-3.8; $P < .05$), and knowing how to perform their work/response duties (OR 2.0; 95% CI, 1.2-3.4; $P < .05$; Table 4). No other demographic variable, attitude or belief question, prior training received, knowledge, or exercise participation was a significant predictor.

Determinants of Willingness to Respond to the Landfill

As with the dirty bomb scenario, first responders' attitudes and beliefs differed significantly when comparing those willing and those unwilling to respond to the landfill scenario (Table 5). On bivariate analysis, those willing to respond to the landfill scenario if requested were significantly more likely than those unwilling to respond to agree that

Table 3. Attitudes and Beliefs Regarding Willingness to Respond to the Dirty Bomb Scenario if Requested

Statement	Willing to Respond If Requested			Willing vs Unwilling P Value ^a
	All Respondents (N=433) Strongly Agree or Agree % (n)	Willing (n=296) Strongly Agree or Agree % (n)	Unwilling (n=137) Strongly Agree or Agree % (n)	
This event could have serious negative health effects.	92.1 (399)	96.3 (285)	83.2 (114)	<.001
My job/role would be important in this event.	91.0 (394)	97.0 (287)	78.1 (107)	<.001
My employer will expect me to work during this event.	89.4 (387)	94.9 (281)	77.4 (106)	<.001
I believe it's my responsibility to work during this event.	82.7 (358)	95.6 (283)	54.7 (75)	<.001
I would be able to perform my work/response duties during this event.	82.0 (355)	90.9 (269)	62.8 (86)	<.001
My coworkers are likely to come to work during this event.	71.1 (308)	83.4 (247)	44.5 (61)	<.001
I know how to perform my work/response duties for this event.	64.7 (280)	73.6 (218)	45.3 (62)	<.001
My family is able to function without me during this event.	60.7 (263)	71.3 (211)	38.0 (52)	<.001
My employer would take precautions to protect me during this event.	56.8 (246)	61.8 (183)	46.0 (63)	<.01
My employer would provide me with adequate PPE.	48.5 (210)	55.7 (165)	32.8 (45)	<.001
I am concerned about radiation exposure from my routine work duties.	43.6 (189)	43.6 (129)	43.8 (60)	NS
I would feel safe working during this event.	37.2 (161)	47.6 (141)	14.6 (20)	<.001
A radiological terrorism attack is likely to occur in St. Louis in the next 5 years.	24.5 (106)	26.7 (79)	19.7 (27)	NS
It would be ethical for responders to refuse to work during this event.	21.9 (95)	20.6 (61)	24.8 (34)	NS

^aDetermined by χ^2 test.

Abbreviations: NS, not significant; PPE, personal protective equipment.

Table 4. Predictors of Willingness to Respond to Radiological Disaster Scenarios When Requested^a

Variable	Willingness to Respond If Requested	
	Dirty Bomb	Landfill
	OR (95% CI)	P Value
I believe it's my responsibility to work during this event.	9.0 (4.5-18.2)	< .001
My coworkers are likely to work during this event.	3.5 (2.0-5.9)	< .001
I would feel safe working during this event.	2.1 (1.1-3.8)	< .05
I know how to perform my work/response duties for this event.	2.0 (1.2-3.4)	< .05
My family is able to function without me during this event.	NIM	NA
	OR (95% CI)	P Value
	17.9 (8.2-38.9)	< .001
	2.1 (1.1-4.0)	< .05
	2.2 (1.1-4.2)	< .05
	NIM	NA
	2.2 (1.2-4.0)	< .05

^aMultivariate logistic regression controlling for gender, occupation, and marital status. Abbreviations: CI, confidence interval; NA, not applicable; NS, not significant; NIM, not included in model because it was not significant; OR, odds ratio.

the event could have serious negative health effects ($\chi^2 = 32.2, P < .001$); have perceived safety working during the event ($\chi^2 = 51.3, P < .001$); believe their employer would provide them with personal protective equipment and take precautions to protect them ($\chi^2 = 18.9$ and $\chi^2 = 20.6$, respectively; $P < .001$); know how to and would be able to perform their duties during the event ($\chi^2 = 57.9$ and $\chi^2 = 55.9$, respectively; $P < .001$); have perceived job importance ($\chi^2 = 55.6, P < .001$); believe their coworkers are likely to work and their employer expects them to work ($\chi^2 = 45.4$ and $\chi^2 = 42.5$, respectively; $P < .001$); have perceived responsibility to work ($\chi^2 = 129.1, P < .001$); and believe their family is able to function without them ($\chi^2 = 44.4, P < .001$). Determinants of willingness to respond if requested to the landfill scenario on multivariate logistic regression controlling for gender, occupation, and marital status included having perceived responsibility to work (OR 17.9; 95% CI, 8.2-38.9; $P < .001$); feeling safe while working during the event (OR 2.2; 95% CI, 1.1-4.2; $P < .05$); believing that their family could function without them during the event (OR 2.2; 95% CI, 1.2-4.0; $P < .05$); and believing their coworkers were likely to work during the event (OR 2.1; 95% CI, 1.1-4.0; $P < .05$). No other demographic variable, attitude or belief question, prior training received, knowledge, nor exercise participation was a significant predictor of willingness to respond when requested.

DISCUSSION

The findings from this study indicate that approximately 30% of first responders would not be willing to respond to a future radiological terrorism scenario if requested, while 27% would not be willing to respond to a nonterrorism radiological scenario if requested. Even if they were required to respond by their employer, response willingness only increased to 85% and 87% for these 2 scenarios, respectively. In this study, willingness to respond to a dirty bomb scenario if requested among first responders was similar (although slightly lower) to that found in a previous study that found that approximately 74% of first responders would be willing to respond to a dirty bomb scenario. Among healthcare workers, findings from previous research indicate that willingness to respond to a radiological disaster scenario ranges from 39% to 76%; the findings from the current study are consistent with the upper end of this range.^{4,5,7,9,14-16}

Similar to the findings from Balicer et al⁹ and Watson et al,¹⁶ the findings from this study identified significant differences in response willingness for radiological disaster scenarios if requested versus if required to respond by the employer. Approximately 85% of first responders in this study were willing to respond to a dirty bomb scenario if required by their employer, but that number decreased to 68% if they were only requested to respond. Similarly, 87% of responders were willing to respond to the radiological landfill scenario if required by their employer, but

Table 5. Attitudes and Beliefs Regarding Willingness to Respond to the Landfill Scenario if Requested

Statement	Willingness to Respond If Requested			Willing vs Unwilling P Value ^a
	All Respondents (N=433) Strongly Agree or Agree % (n)	Willing (n=316) Strongly Agree or Agree % (n)	Unwilling (n=117) Strongly Agree or Agree % (n)	
This event could have serious negative health effects.	90.8 (393)	95.6 (302)	77.8 (91)	<.001
My job/role would be important in this event.	88.2 (382)	95.3 (301)	69.2 (81)	<.001
My employer will expect me to work during this event.	87.1 (377)	93.4 (295)	70.1 (82)	<.001
I would be able to perform my work/response duties during this event.	82.9 (359)	91.1 (288)	60.7 (71)	<.001
I believe it's my responsibility to work during this event.	82.2 (356)	96.5 (305)	43.6 (51)	<.001
Landfill currently poses a risk of cancer to those nearby.	76.7 (332)	77.2 (244)	75.2 (88)	NS
Landfill currently poses a risk of radiation exposure to those nearby.	75.1 (325)	76.3 (241)	71.8 (84)	NS
My coworkers are likely to come to work during this event.	71.4 (309)	81.3 (257)	44.4 (52)	<.001
I know how to perform my work/response duties for this event.	70.2 (304)	80.4 (254)	42.7 (50)	<.001
My family is able to function without me during this event.	61.0 (264)	71.8 (227)	31.6 (37)	<.001
My employer would take precautions to protect me during this event.	57.0 (247)	63.6 (201)	39.3 (46)	<.001
I am concerned about the health of my family/friends due to the landfill.	50.3 (218)	52.2 (165)	45.3 (53)	NS
My employer would provide me with adequate PPE.	49.7 (215)	56.0 (177)	32.5 (38)	<.001
Nonterrorism radiological event is likely to occur in St. Louis in the next 5 years.	45.7 (198)	47.5 (150)	41.0 (48)	NS
I would feel safe working during this event.	44.3 (192)	54.7 (173)	16.2 (19)	<.001
I am concerned about radiation exposure from my routine work duties.	43.6 (189)	43.7 (138)	43.6 (51)	NS
I am concerned about my own health due to the landfill.	40.9 (177)	43.0 (136)	35.0 (41)	NS
The landfill isn't a health risk now but could be in the future.	29.6 (128)	30.1 (95)	28.2 (33)	NS
It would be ethical for responders to refuse to work during this event.	27.5 (119)	26.6 (84)	29.9 (35)	NS

^aDetermined by χ^2 test.

Abbreviations: NS, not significant; PPE, personal protective equipment.

willingness dropped to 73% if requested to respond. This confirms an initial hypothesis of the researchers that is consistent with previous research: Willingness is higher when required versus requested. The Watson et al study¹⁶ saw response willingness among hospital workers drop from 75% if required to 64.5% if requested, while Balicer et al⁹ reported a decrease from 72% if required to 61% if requested.

These significant differences between response willingness if requested versus required have important implications for emergency response planning. Disaster planners need to be aware of the number of responders likely to help during emergencies and adjust operational plans accordingly. These findings are also important for first responder agency administrators, who should recognize that organizational policies (or the lack thereof) outlining attendance expectations and job duties during disasters will affect the number of employees who present to work. These policies should clearly describe the potential ramifications if responders choose not to work during a disaster. Administrators should carefully explore the legal and ethical ramifications of implementing such policies.¹⁷⁻²¹ For example, consideration should be given to how and when employees are initially informed of work requirements during disasters and the consequences for nonresponse, as well as the resulting impact of these expectations on employees' family roles and work/life balance.²¹

This study found a significant difference in willingness to respond to a radiological terrorism scenario versus a non-terrorism scenario. Among all respondents, 73% were willing to respond to the landfill scenario if requested, but only 68% were willing to respond to the dirty bomb scenario if requested. This is likely due to differences in perceived susceptibility and risk between the 2 scenarios. While almost all respondents agreed that both the dirty bomb scenario and the landfill scenario could have serious negative health effects (92% vs 91%, respectively), only 37% agreed that they would feel safe working during the dirty bomb scenario, compared to the 44% who would feel safe working during the landfill scenario. Differences in anticipated job duties may have also contributed to the contrast in response willingness between the 2 scenarios. In the scenario descriptions provided in the survey, respondents were informed that they would be responding at the site of the dirty bomb detonation; however, in the landfill scenario they could be responding at the landfill or assisting with evacuations in surrounding neighborhoods. This difference in physical proximity to the source of radiation may have made some respondents feel that the landfill scenario represented a lower risk and was therefore less dangerous.

As with previous research,^{9,10,16} multiple attitudes/beliefs and perceptions were found to be significant predictors of willingness to respond. In particular, self-efficacy was found to be a strong predictor of willingness to respond to the dirty bomb scenario. Respondents who indicated that they knew how to perform their job duties during the scenario were twice as likely to respond as those who did

not know how to perform their job duties. Perceived susceptibility was also a strong determinant of response willingness; in both scenarios, respondents who felt safe working during the disaster were twice as likely to respond as those who did not feel safe. These constructs represent 2 potential targets for interventions to improve response willingness among first responders. Based on these findings, education and training programs could be developed that discuss expected job duties during disasters and that introduce techniques and equipment used to promote safe work practices; this would theoretically increase the proportion of workers who would be willing to work during a radiological disaster.

Similar to the findings of earlier studies,^{6,9,16} normative beliefs were strong determinants of response behavior. A belief that there is a responsibility to work during a radiological disaster was the largest predictor of response willingness for both radiological disaster scenarios used in this study; first responders who agreed with this statement were 9 times more likely to work during the dirty bomb scenario than those who disagreed, and they were almost 18 times more likely to work during the landfill scenario than those who disagreed. The anticipated behavior of coworkers was also an important predictor of response willingness; responders who agreed that their coworkers would likely report to work during the disaster were over 3 times more likely to work during the dirty bomb scenario and more than twice as likely to work during the landfill scenario compared to those who disagreed.

Perception of family preparedness during disasters was another important predictor of response willingness in this study. First responders who agreed that their family was able to function without them during a disaster were twice as likely to work during the landfill scenario as those who disagreed. This odds ratio is lower than that reported by Balicer et al,⁹ who found that hospital workers were almost 8 times more likely to work during a radiological disaster if they felt that their family was prepared to function without them. The difference in findings could be due to several factors. In the current study, perception of family preparedness was a significant predictor of response willingness for the landfill scenario but not the dirty bomb scenario; the 2011 study described only a dirty bomb scenario. Second, the subjects included in the studies were from 2 different populations—that is, first responders versus hospital workers. Finally, there are marked differences in subject composition between the 2 studies; in this study, almost 90% of participants were male, while almost 75% of the participants in the 2011 study were female. Perceptions and expectations of gender roles in the family can influence behavior; for example, Qureshi et al⁴ found that female healthcare workers were less willing to work during disasters than male healthcare workers, particularly when there were childcare obligations at home. It is possible that the relationship between perceived familial preparedness and response willingness in the current study is also influenced by gender.

This study had several strengths. It is the first such study that attempted to measure and compare willingness to respond to radiological terrorism and nonterrorism scenarios among first responders. It is also the first to assess firefighters' willingness to work during radiological disasters of any type. However, there are some limitations. Because of the composition of the participating agencies, study respondents were mostly white males with 11 or more years of work experience. There were also significant differences in several demographic variables between the occupational groups. The participants in this study were from the St. Louis metropolitan area only; therefore, the findings may not be generalizable to all first responders or other responder agencies nationwide. Social desirability bias may have influenced participants to indicate that they would be willing to respond to the radiological disaster scenarios on the survey, although this bias should have been minimized because the survey was anonymous.

CONCLUSION

Findings from this study indicate that willingness to respond to radiological disasters among first responders differs significantly between terrorism and nonterrorism scenarios, and whether responders are requested to respond versus required to respond by their employer. Normative beliefs, perceived susceptibility, self-efficacy, and perceived barriers are strong predictors of response willingness during these disasters. These constructs can be targeted through intervention to increase the number of first responders who are willing to respond. First responder agency administrators should also consider implementing organizational policies that define expectations of employee response during disasters.

ACKNOWLEDGMENTS

This work was supported by the National Institutes of Health CTSA under grant number UL1TR002345.

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*Manuscript received December 26, 2019;
revision returned February 21, 2020;
accepted for publication March 30, 2020.*

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